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ECL 188A

THE STUN-GUN (A)

"MBAssociates' new product is the Stun-Gun, a non-lethal system it calls 'the most versatile device in law enforcement weaponry'. The unit includes a Stun-Stik, a riot baton extension and a variety of cartridges specially designed for taming unruly demonstrations and protests without killing anyone.

"The Stun-Gun has been winning applause and praise from sheriffs and police departments, industrial security and private guards, campus police, National Guard units and government agencies."

London Financial Times

 Written by Mr. A. P. Shack, Stanford University, and Professor G. Kardos, Carleton University, with financial support from the National Science Foundation. The assistance of Mr. Robert Mawhinney and MBAssociates is gratefully acknowledged.

"The conception and design of the Stun-gun weren't the same as our usual project", recalls Bob Mawhinney, Manager of Ordnance Systems at MBAssociates. "There wasn't a set of requirements available which stated what had to be done. It was more that a problem existed and in my position I was able to spend some time on it. Once we came across some key features we were able to set our own requirements and could make sure we met them."

Bob Mawhinney is a mechanical engineering graduate from Auburn University (1959) with a Master's degree from University of California-Berkeley (1969). He had spent four years in the navy working on ordnance devices. On his discharge in 1963 he joined MBAssociates where he had worked himself up to his present position.

MBAssociates (MBA) is, for its size, 250 employees, one of the most advanced high-technology companies. Forty percent of its employees hold advanced degrees. It was established in 1960 in San Ramon, 30 miles from San Francisco. For its first seven years it remained an R&D company developing the technology of miniature rocketry and acquiring a highly skilled engineering-scientific team. In 1967 MBA expanded its base and obtained development and production contracts in unconventional ordnance devices, weaponry systems and specialized computer hardware.

In 1969 MBA and Bob decided to look into the area of non-lethal weapons. It had occurred to Bob that the law enforcement agencies had no suitable weapon between hand-to-hand combat and lethal firearms. The response available could not always match the threat. It was about this time that the Kent State incident sharply focused on the need for a non-lethal weapon.

Bob's search started by finding all there was to know about the non-lethal weapons developed in the last ten years. Table 1 lists a number of these systems. The search uncovered little documentation on their development or on their effectiveness. Bob found "Most of the items were developed by people who just came up with wild new ideas, tried them and for some reason or other did not get anywhere, so dropped them."

Early discussions with law enforcement agencies indicated that a device with a range greater than a nightstick was needed. The nightstick was quite effective at close-range but something was needed which would reach out about 100 feet. A projectile or impact type device was called for.

LOW-LETHALITY DEVICES

Nightstick-Baton	Light
Firearms	Sound
Animals Horses Dogs	Projectiles Mass Markers Bolas Net-Snares Stenches Sticky Tape, Blob, etc. Barbed Wire
Barriers Barbed Wire Ropes Foam Slippery Material	Smoke
Waterhose	Chemicals Grenade Bulk Release Darts Baton Vomiting Agents Pepper Itching Powder Foam
Electrified Devices Baton Vehicles Hose	
Heat	
Cold Projector	

TABLE 1

Bob recalls, "In order to design an effective device we had to decide exactly what it was that could stop a rioter." The literature revealed very little. The only useful item was a Department of Defense report which suggested Kinetic Energy as the critical factor. It also showed that if enough K.E. was delivered to stop a man in his tracks it was extremely close to causing serious irreversible injury. Bob was unwilling to accept these conclusions. "We have all seen people hit by a pitched hardball, which has the same K. E. as a .22 bullet, without serious injury. I, for one, would certainly rather take a few licks from a baseball than from a .22." These considerations led Bob and his team to suggest K. E. per unit area as a better measure of impact tolerance. They suspected that the Department of Defense report was probably correct as far as it went but it was limited to projectiles less than 1.5 inches in diameter.

Bob listed the characteristics of various lethal and non-lethal weapons (Table 2). "In making the tabulation, there

CHARACTERISTICS OF FAMILIAR OBJECTS

	Billy* Club	Baseball* Bat	Baseball	Golf Ball	Cal .22 Long Rigle High Vel.	Cal .38 Special Bullet	Cal .45 Automatic Bullet
Velocity, ft/sec	12.	20.	140.	250.	1125.	1065.	850.
Mass, lb_m	1.9	2.3	0.32	0.11	0.0057	0.021	0.033
Diameter, in.	1.5	2.3	2.9	1.7	0.22	0.38	0.45
Impact area, $in.^2$	1.	1.	2.5	1.	0.035	0.11	0.16
Kinetic Energy, ft-lb_f	4.3	14.	97.	110.	112.	377.	369.
Momentum, lb_f-sec	0.7	1.4	1.4	0.9	0.2	0.7	0.9
$MV^{3/2}$, $lb_m(ft/sec)^{3/2}$	80.	200.	530.	570.	215.	730.	820.
Kinetic Energy per Unit Area, ft-lb_f/in^2	4.	14.	40.	100.	3200.	3400.	2300.

*Does not include the arms of the user.

TABLE 2

was a certain amount of estimating. All the projectiles were cylindrical or spherical and there is a geometric mismatch with the body contours. Therefore, we had to estimate what the contact area was. It required a little bit of hand-waving, but we think reasonable areas were arrived at." This data seemed to confirm that K.E./Area gave a more realistic estimate of how lethal a projectile was than K.E. alone. (Data accumulated since the development of the Stun-Gun indicates that the duration of impact also is a factor.) It was decided that a weapon having the stopping power (K.E./A) approximately equal to a fast pitched baseball was wanted and that the projectile should also have minimum geometric mismatch with the body. Preferably it should be a deformable projectile which could conform to the body contour on impact.

Up to this point Bob had been the principal investigator but he was not working alone. As on all projects at MBA the engineers discuss their problems with one another, making suggestions and trying out ideas on one another. It was often hard to trace where ideas originated or who contributed which idea. At this point the project bogged down. It had been a sporadic effort over a couple of years, but now no one could readily see any way to deliver a large area projectile out of anything but a large bore gun: a 4 inch projectile from a 4 inch gun. A gun of this size was impractical. The project was thus discontinued. There seemed to be no solution to this seemingly insurmountable conflict in requirements.

Although no further formal effort was put into the project, Bob and his companions kept turning over ideas and the project was kept in the back of their minds. After a few months, the idea of using a spin stabilized bean bag suddenly occurred to Bob. "It kind of just popped into mind. It's not clear exactly how it happened. It was simple. A circular bean bag could be folded into a small bore gun. When the bag is fired from the gun the bag would engage the rifling and be given a spin. Once out of the barrel, centrifugal force would cause it to open up and fly downrange, broadside, like a lead hamburger." (Exhibit A-1)

The idea sounded right but would it actually work? Would its flight be stable? Bob decided that he should run through some numbers just to establish if the idea was feasible. For a start he selected the M-79 Grenade Launcher as a gun. (Exhibit A-1) It had a bore of 40mm (1.5 inches). This was a weapon MBA had some experience with and it was already in the possession of the military. If the idea was successful it could be implemented immediately without having to design a special weapon. The M-79 has rifling which gives 1 turn in 4 feet.

"It sounded like a wild idea" recalls Bob. "I wasn't sure I was right. After the fact, of course, it is obvious. There is probably some elegant way to calculate whether a projectile, like a bean bag, is dynamically stable. When I did the numbers I used a simplified method. I just assumed the projectile acted like a rigid projectile in both configurations."

Bob started by assuming his projectile was 1.5 inches in diameter and 3 inches long in the barrel of the launcher and weighed approximately .32 lbs., and that after launching at 100 ft. per sec. it would open up to a 4 in. diameter disk.

The standard formula for determining the minimum spin rate for stable flight used at MBA was

$$\Omega_r = \left[\frac{6\rho V^2 I_{yy}\ S\ell\ (C_{\ell\alpha}+C_D)}{I_{xx}}\right]^{1/2}$$

This formula can be derived from the gyrodynamics of a spinning top and the aerodynamics of flight. (Exhibit A-2)

Ω_r = spin rate

ρ = air/density

V = forward velocity

I_{yy} = moment of inertia perpendicular to spin axis

I_{xx} = moment of inertia about spin axis

S = frontal area of projectile

ℓ = characteristic length of projectile

$C_{\ell\alpha}$ = slope of lift coefficient curve

C_D = drag coefficient

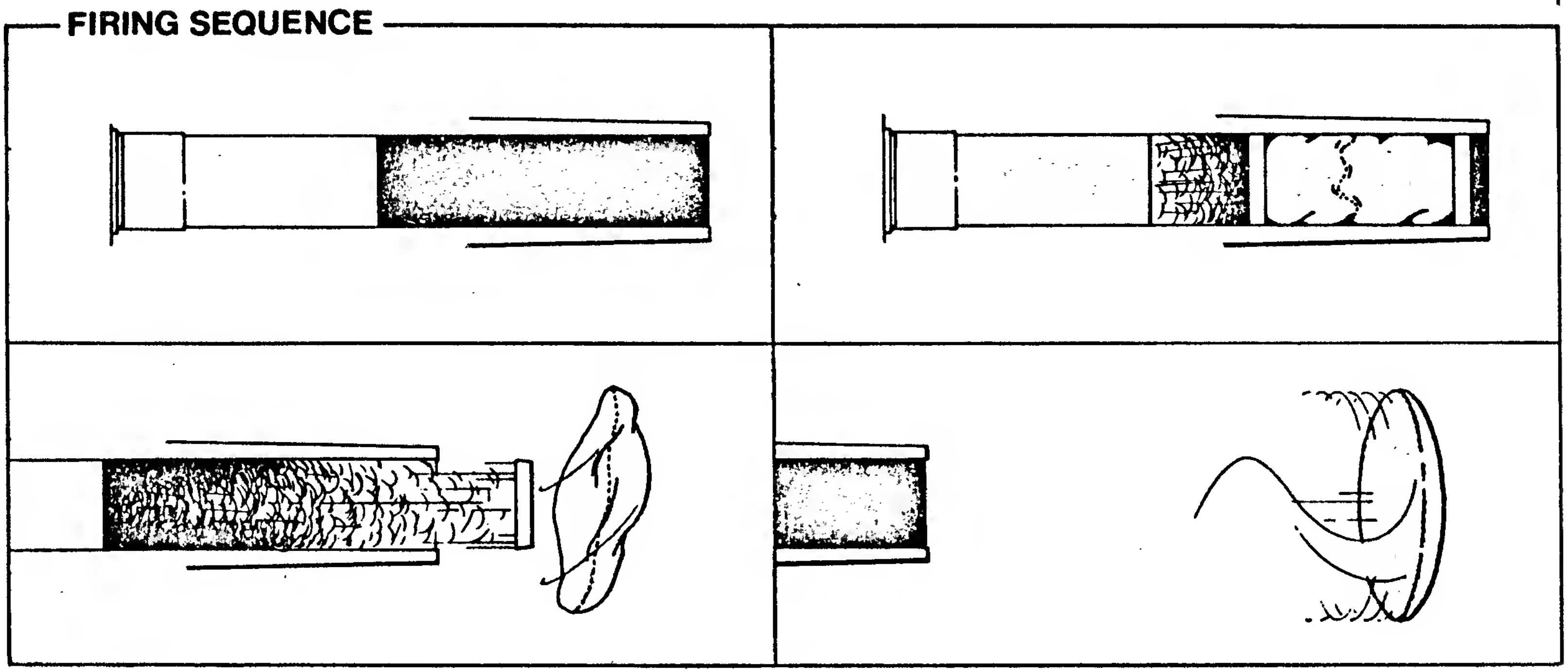
For Bob's purposes exact values of the terms were not needed. He assumed

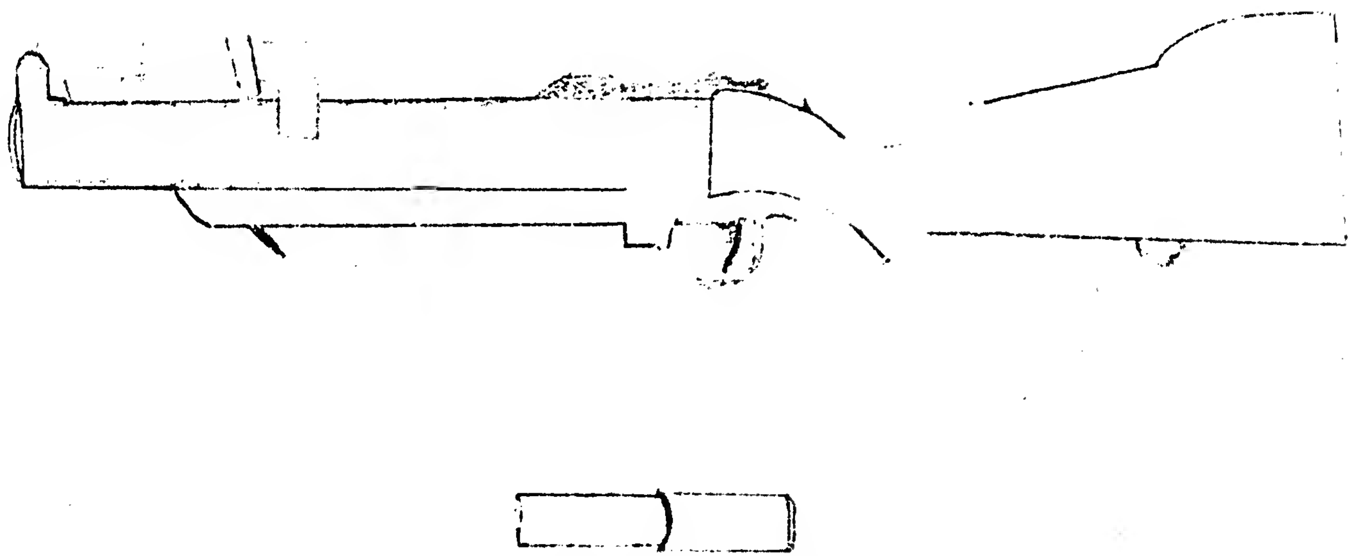
ℓ = half the length of projectile

$C_{\ell\alpha}$ = 2

C_D = 1

Bob's calculations showed that the projectile could be stable if he dropped the safety factor of $\sqrt{3}$ in the formula. By adjusting some of the factors he was satisfied that he had a viable system. His task was now to convince his management that his scheme would work and that it was worth pursuing to completion.



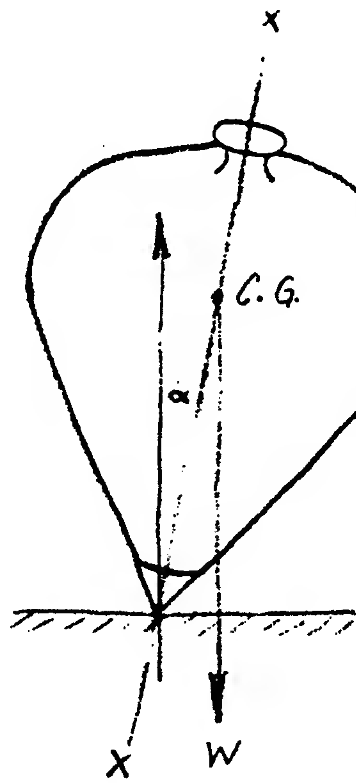


M-79 GRENADE LAUNCHER WITH CARTRIDGE

EXHIBIT A-1

STABILITY OF PROJECTILES
(From "Elements of Ordnance" by Hayes)

The motion of the axis of the top about the vertical is said to be stable if its axis moves for a considerable time in the vicinity of the vertical, even if it has a small perturbation.



The condition for stable motion about the spin axis exists when

$$\frac{I_{xx}^2 \, \Omega_r^2}{4 I_{yy} \mu} > 1$$

Where μ is the moment factor such that the overturning moment about the transverse axis M_{yy} is given by

$$M_{yy} = \mu \sin\alpha$$

In the case of a flying projectile the overturning moment is generated by aerodynamic drag and lift both of which are dependent on α

$$M = \rho V^2 S \ell (C_{\ell\alpha} + C_D) \sin\alpha$$

EXHIBIT A-2

THE STUN-GUN (B)

Bob Mawhinney's search for a non-lethal weapon had led him to postulate the firing of a bean bag like projectile from the M-79 grenade launcher. This type of projectile, if it could be made to fly broadside down range (Exhibit A-1), would have the same K.E./unit area as a baseball. Thus it could be used to stop a rioter without causing irreversible injury.

After carrying out preliminary calculations on the stability of such a projectile (Exhibit B-1), Bob was convinced that his idea was feasible and could be made to work. His first simplified assumptions showed marginal stability only after removing the safety factor $\sqrt{3}$ from the formula. By increasing the density of his projectile and assuming a more advantageous configuration in flight he was able to show that stable flight was possible. For patent purposes he had one of his colleagues initial these calculations. But, could he convince anyone else that this wild idea was worth pursuing?

When Bob tried to convince management that maybe they should try it, they said, "You've got to be kidding There is no way that it will fly broadside like that." It seemed so wild they didn't want to spend the time or the money to try it. But such a rejection doesn't kill a good idea. It only means that the idea doesn't have a formal status or budget in the company. Working on his own and with discretion, Bob was able to fabricate a few projectiles and try a few tests. It worked! High speed movies of the projectile showed it flying down range broadside.

With this demonstration of feasibility the idea immediately became a fully authorized project. As Bob said, "It flew and everything got cranked up."

A prototype was assembled and tests were run with the special bean bag cartridge (Exhibit B-2). Tests were carried out with various sizes and shapes of projectiles to find the optimum bag configurations. From these tests, a three inch diameter, 1/3 pound, pancake-like bag filled with lead shot eventually emerged as a suitable projectile. The projectile gave a performance having the same K.E. as a .22 bullet but more uniformly distributed to give a K.E./Area of less than a fast pitched baseball.

CHARACTERISTICS OF STANDARD STUN BAG

Velocity, ft./sec.	155
Mass, $lb._m$	0.30
Diameter (expanded), in.	3.0
Impact Area (expanded), $in.^2$	7.1
Kinetic Energy, ft.-$lb._f$	112
Momentum, $lb._f$-sec.	1.5
Kinetic Energy Per Unit Area, ft.$lb._f/in^2$	16.0

"We then went around to talk to people who knew about non-lethal weapons" recalls Bob. "We fully expected to hear 'Oh, that old spin stabilized bean bag trick again!' but everyone we spoke to was encouraging and we felt we might be on the right track."

With a working projectile the next step was to find what effect such an impact would have on the human body. The automotive industry had more information on blunt impact than enyone else. They also had human damage data correlated against fully articulated and instrumented dummies. Although the stun-gun impact wasn't identical to auto impact, the automotive information was a body of data against which it could be compared. A special consultant in the field of bio-mechanics, Dr. V. L. Roberts, was brought in to work with Bob on the impact tests.

The stun-gun was tested by firing several bags of different mass with different muzzle velocities at the articulated dummies. The results were promising. As Bob said, "Bio-mechanics is a giant grey area with no clear cutoffs. Eventually, based on someone's 'gut-feel' for what is lethal and what is not, we figured we had a non-lethal weapon." The final configuration might knock the target off their feet but would do no permanent damage. The severity index calculation (Exhibit B-3) showed that it would be classed as in the soft range.

The stun-gun still hadn't been tried on a live target. A Berkeley policeman volunteered to take a shot. He was outfitted with a catcher's mask and pads and the gun was fired at him from 35 feet. The first shot missed completely. The second shot missed the padding and clipped him on the upper arm. He was very impressed by its incapacitating ability! The pain doubled him up and brought tears to his eyes. It was several minutes before he would even permit anyone to look at his arm. Much later he stated that in that condition you could have lead him away with one finger. The impact of the bag raised a large bruise on his arm but no permanent damage was done. The assistance of a doctor was not needed. The test was a success.

The original objective had been to provide a riot control weapon for the military. Thus the selection of the M-79 grenade launcher was a wise one since this weapon was already available to the armed services. However when civilian law enforcement agencies heard about the weapon, they decided that they should have it. This lead to complications since the M-79 was not available to non-military agencies. There

was a strong incentive to supply a system for these civilian agencies. They could usually move faster than the military, and if a system were available they could place orders for them immediately.

With a successful system in hand it was decided that a system should be designed for sale to the civilian police. Since the M-79 could not be used, a launcher would also have to be provided. The police were reluctant to have to carry an extra weapon so they asked that the weapon be designed so that it could also function as a club or riot baton. To reduce tooling and inventory, MBA decided that the same cartridge would be used for both the M-79 and the police gun, but the military insisted that the police gun should not take the regular M-79 cartridges since they are classified as semi-artillery. In addition to these principle requirements it was decided that the police gun should have a positive safety (not being able to fire if the breech is not fully closed), be fast loading, be low in cost (M-79 cost is $180, the ammunition, $7.00 per round), and it was established that it need not be multi-shot.

The project had developed to sufficient size that some of the design responsibility could be divided. Bob Mawhinney continued to control the overall system concept. S. F. Mulich took responsibility for the design of the police baton gun and J. Cammorata took over the cartridge design.

①

Bean Bag

1. M79 spins at ~ .25 rev/ft

So @ 100 fps

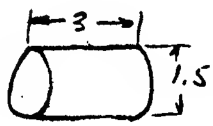
$$\Omega_1 = \frac{.25\ \text{rev}\ 100\ \text{ft}\ 2\pi\ \text{rad}}{\text{ft}\ \text{sec}\ \text{rev}} = 157\ \text{rad/sec}$$

To conserve angular momentum

$$M = I_{xx_1}\Omega_1 = I_{xx_2}\Omega_2$$

so $$\Omega_2 = \frac{I_{xx_1}}{I_{xx_2}}\Omega_1$$

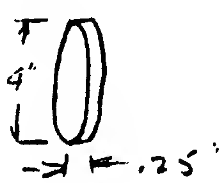
Assume



before and ≈ .32 lbs

$$\text{Vol} = .785 \times 2.25 \times 3 = 5.3\ \text{in}^3$$

so after it could be



∴ Before

$$I_{xx_1} = \frac{1}{2}wr_1^2 = \frac{.32\ \text{lb}_m\ .56\ \text{in}^2\ \text{ft}^2}{2 \times 144\ \text{in}^2} \qquad \frac{8\times10^{-1}\times6\times10^{-1}}{2\times1.45\times10^2}$$

$$= 6.25 \times 10^{-4}\ \text{lb}_m\ \text{ft}^2$$

$$I_{yy_1} = \frac{1}{12}w(3r_1^2 + h_1^2) = \frac{.32\ \text{lb}_m}{12 \times 144}(1.7 + 9) \qquad \frac{3\times10^{-1}\times10}{10\times1.5\times10^2}$$

$$= 2 \times 10^{-3}\ \text{lb}_m\ \text{ft}^2$$

After

$$I_{xx_2} = \frac{1}{2} w r_2^2 = \frac{6.25\times10^{-4}}{.56} \times 4 =$$

$$= 4.46 \times 10^{-3}\ lb_m\,ft^2$$

$$I_{yy_2} = \frac{1}{12} w (3r_2^2 + l_2^2) = \frac{2\times10^{-3}}{10.7} \times 12.06$$

$$= 2.26 \times 10^{-3}\ lb_m\,ft^2$$

Spin rate (rad/sec) required for stability is

$$\Omega_r = \left[\frac{6\ \rho V^2 I_{yy} S\, l_2^2 (C_{L\alpha} + C_D)}{I_{xx}^2}\right]^{1/2} = \frac{\cancel{lb_m}}{\cancel{ft^3}} \frac{ft^2}{sec^2} \frac{\cancel{lb_m}\,\cancel{ft^2}}{\cancel{lb_m^2}\,\cancel{ft^4}}\ \cancel{ft^2}\ \cancel{ft}$$

Before

$$\Omega_{r_1} = \left[\frac{6\times.076\times10^4\times2\times10^{-3}\times.785\times2.25\times1.5\times3}{144\times12\times6.25\times6.25\times10^{-8}}\right]^{1/2}$$

$$\sim \left[\frac{6\times8\times10^{-2}\times10^4\times2\times10^{-3}\times\cancel{8}\times\cancel{10^{-1}}\times\cancel{10}}{\cancel{2}\times10^3\times\cancel{4}\times10\times10^{-8}}\right] = (9.6\times10^4)^{1/2}$$

3×10^2

$$= (10.7\times10^4)^{1/2} = \cancel{338}\ 3.28\times10^2 \text{ radians/sec}$$

After $$\Omega_{r_2} = \left[\frac{6\times.076\times10^4\times2.26\times10^{-3}\times.785\times16\times.125\times3}{144\times12\times4.46\times4.46\times10^{-6}}\right]^{1/2}$$

$$= \left(\frac{6\times8\times\cancel{10^{-2}}\times\cancel{10^4}\times\cancel{2}\times\cancel{10^{-3}}\times8\times\cancel{10^{-1}}\times\cancel{15}\times10^{-1}\times3}{\cancel{15}\times10^3\times\cancel{2}\times10\times10^{-6}}\right)^{1/2}$$

$$= (14.1\times10^2)^{1/2} = 37.6 \text{ radians/sec}$$

So out of the M79

$$\Omega_2 = \frac{I_{xx_1}}{I_{xx_2}} \Omega_1 = \frac{6.25 \times 10^{-4}}{4.46 \times 10^{-3}} \times 157$$

$$= 22 \text{ rad/sec}$$

Since in the after condition we require 37.6 rad/sec the stability is probably poor. However the spin rate eqn contains a factor of safety of $\sqrt{3}$

$$\Omega_{min} = \frac{\Omega_{r_2}}{\sqrt{3}} = \frac{37.6}{1.732} = \underline{\underline{21.7 \text{ rad}}}/\text{sec}$$

So it just might fly!!

What can be changed to be safer

$$\Omega_r = \frac{\cancel{4 \times 6}\, \rho V^2 \cancel{\alpha} (3r^2 + h^2)\, \pi \cancel{r}\, h\, C}{\cancel{12 \times 4} \times W^2 r^{4\,2}}$$

$$= \left[\frac{\pi \rho V^2 h C (3r^2 + h^2)}{W r^2}\right]^{1/2}$$

So increasing weight helps. The calc. was based on .32 lb

$$W = .32 = Vol\, \rho$$

$$\rho = \frac{.32 \text{ lb}_m \times 1728 \text{ in}^3}{5.3 \text{ in}^3 \times \text{ft}^3} = 104 \text{ lb}_m/\text{ft}^3$$

This would be like sand which is like 90-120 lb/ft³

∴ We could use glass beads or marbles 150-175 lb/ft³

or Plaster of Paris 144 - "

Table Salt 130

Steel BB's 480

Slowing Down Length

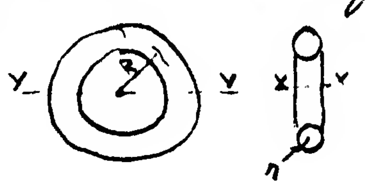
$$\lambda = \frac{2M}{\rho A C_D} = \frac{2 \times .32 \times 144}{.076 \times 16 \times .785}$$

$$\frac{6 \times 10 \times 1.5 \times 10}{8 \times 10^{-2} \times 1.5 \times 8 \times 10^{-1}}$$

$$\lambda = 9.7 \times 10 = 97\ ft$$

Thats OK

Assume the final configuration is a torus



Let $R = 1.5\ in$

$r = .5\ in$

$$I_{xx} = W\left(R^2 + \tfrac{3}{4}r^2\right) = \frac{.32\ (2.25 + .19)}{144}$$

2.44

$$\frac{3 \times 10^{-1} \times 2.5}{1.5 \times 10^{2}}$$

$$= 5.4 \times 10^{-3}\ lb_m\ ft^2$$

That some help.

So dimensionless spin rate ν

$$\nu_2 = \frac{2r\Omega}{V_{axial}} = \frac{2 \times 2 \times 22}{100 \times 12} = .074\ rad/cal$$

$$\nu_1 = \frac{2 \times .75 \times 157}{100 \times 12} = .196\ rad/cal$$

Hoop Stress in bag due to loose payload

$$\sigma = \frac{\rho_{pay} \, \nu^2 V_{Bo}^2 \, d}{24 \, g_c \, t} \qquad t = ?? \text{ say } .032$$

$$= \frac{480 \times .074^2 \times 10^4 \times .33}{24 \times 32.2 \times .032}$$

$$\approx \frac{5\times10^2 \times \cancel{5}\times10^{-3} \times 10^4 \times 3\times10^{-1}}{\cancel{2.5}\times10 \times 3\times10 \times 3\times10^{-2}} \sim 300$$

EXHIBIT B-1

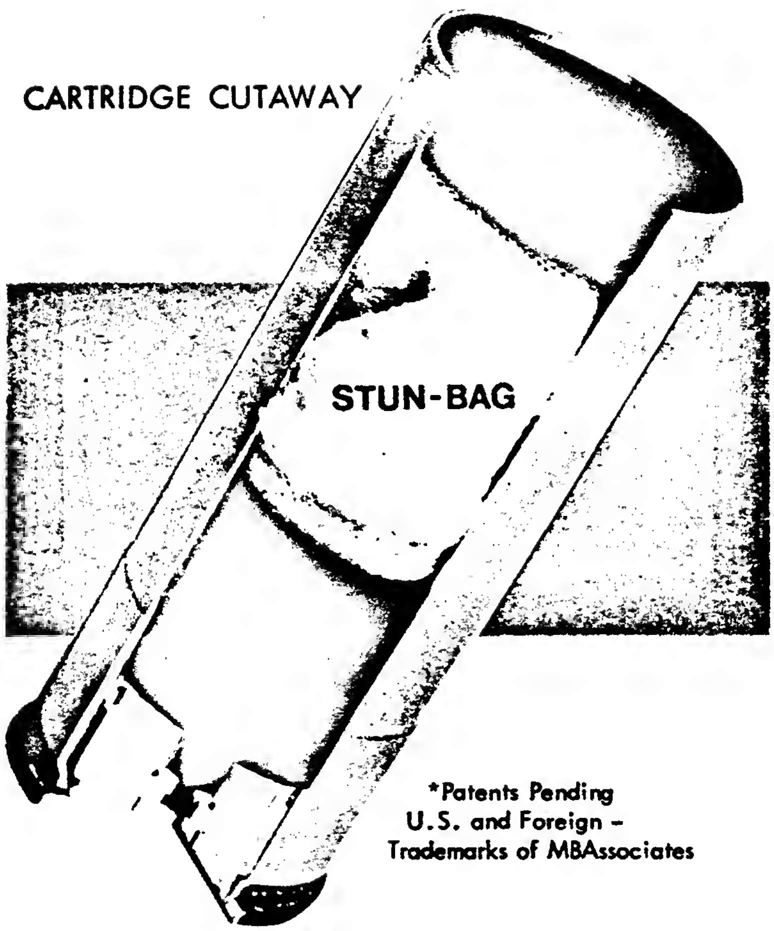

CARTRIDGE CUTAWAY
STUN-BAG
*Patents Pending
U.S. and Foreign -
Trademarks of MBAssociates

EXHIBIT B-2

Excerpts from
"HUMAN IMPACT TOLERANCE"

S.A.E. Paper 700399
by
A. Wisner, J. Leroy, and J. Bandet

1. The human body . . . cannot be considered as an object whose mechanical characteristics would be uniform . . . the fact must be stressed that the seat of the injury is more significant for survival than the importance of the forces brought into play.

2. The speed, angle of impact, resistance of the hit object (the bean bag), the vehicle (ourselves), the forces acting . . . the variation of their intensity, duration and direction.

3. It has been shown that the tolerance limits for human subjects approximates a 50g peak at 500g/sec. of acceleration for .25 sec. duration provided . . . impinge on . . . shoulders and hips.

4. Bodily injuries may be caused by weak energies so long as they are transmitted in a very long time over a small surface.

5. Necessary K.E. to fracture the skull . . . 4.5 to 10 kgm.

6. Concussion . . . 3 to 7 kg/cm^2 during at least 1 m.s.

7. Severity index

$$I = \int_{t_0}^{t_s} a^n dt \qquad I < 1.000 \text{ (no injury)}$$

where: a = acceleration during impact (in "g")
t = time (in sec.) of impact duration where

$$1 \text{ ms} \leq t \leq 50\text{ms}$$

n = panebration factor (varies with the part of the body hit, n = 2.5 for the head).

EXHIBIT B-3

THE STUN-GUN (C)

The new civilian model of the Stun-Gun (Exhibit C-1) was designed by S.F. Mulich, and a prototype built. The 40mm bore was kept to remain compatible with the M-79 military grenade launcher. The civilian model was designed with a threaded hole in its base to permit the addition of an extension bar into the stock (Exhibit C-2). With the extension the Stun-Gun was riot baton size. Without the extension it was about the size of a night stick. The barrel of the gun was made of tough plastic to withstand large impact loadings.

A circular band of metal with a notch in it was wrapped around the firing pin slot. When the notch did not line up with the firing pin the pin could not strike the cartridge. A trick breech similar to that of an old two barrel shotgun was used on the gun for ease and speed of loading.

The first model was machined out of a solid piece of metal. This proved to be too expensive and later models were made of molded injected plastic (lexon). The only metal in the gun besides the firing mechanism is an aluminum barrel liner. The entire stun-gun with extension weighs only slightly more than a riot baton.

The cartridges use gun powder as a propellant. The cartridge casing is similar to the standard 40mm round. It differs in that the shoulder of the stun shell is slightly shorter (Exhibit C-3). The chamber of the stun-gun is made to match the short shouldered cartridge. Thus if a military shell is put into the police gun it will not fit. However, the stun shells easily fit into the M-79.

While the specialty of the stun-gun was the bean bag shell, an assortment of different types of cartridges can be made for the gun. A few examples of these are: a bag loaded with dye to mark the target, tear gas shells, double range shell (200 ft. range), etc.

The entire system, with extension, was designed for either shoulder or hip firing. While there is no actual sight, the barrel is tapered and lines up with the target at maximum range when shoulder fired.

The cost of the system was reduced from the $180 for the M-79 to about $60 for the Stun-gun. As a further reduction in cost, the rounds can be reloaded by the owner of the gun. While the new round cost $7, the reloading kit costs only $.25.

The Stun-gun is not available for purchase by everyone. The government has put strong laws on who may and may not purchase them. At this point they are sold only to military and police organizations. While there is no actual registration, careful track is kept by serial number of who buys a gun.

The Berkeley police bought several guns and have used them in the field in December 1970 (Exhibit C-4). The results were satisfactory. "There were no hits but some spectacular near misses. When a rioter heard and/or saw one of these bags tear through a hedge next to him, he dropped the rocks that he was carrying and fled." An unforeseen bonus was that the 1.5 in. barrel had a tremendous intimidation factor. Rioters carefully moved so that they were out of line of the massive looking gun barrel.

Patents were applied for throughout the development of the system as each feature developed. The system is now covered by about a dozen interlocking patents covering the various details of the device.

Bob looks back with some satisfaction on the development of the stun-gun. He had satisfactorily met an unstated need and moved his firm into a new and profitable business. (Exhibit C-5).

MBA stun·gun™

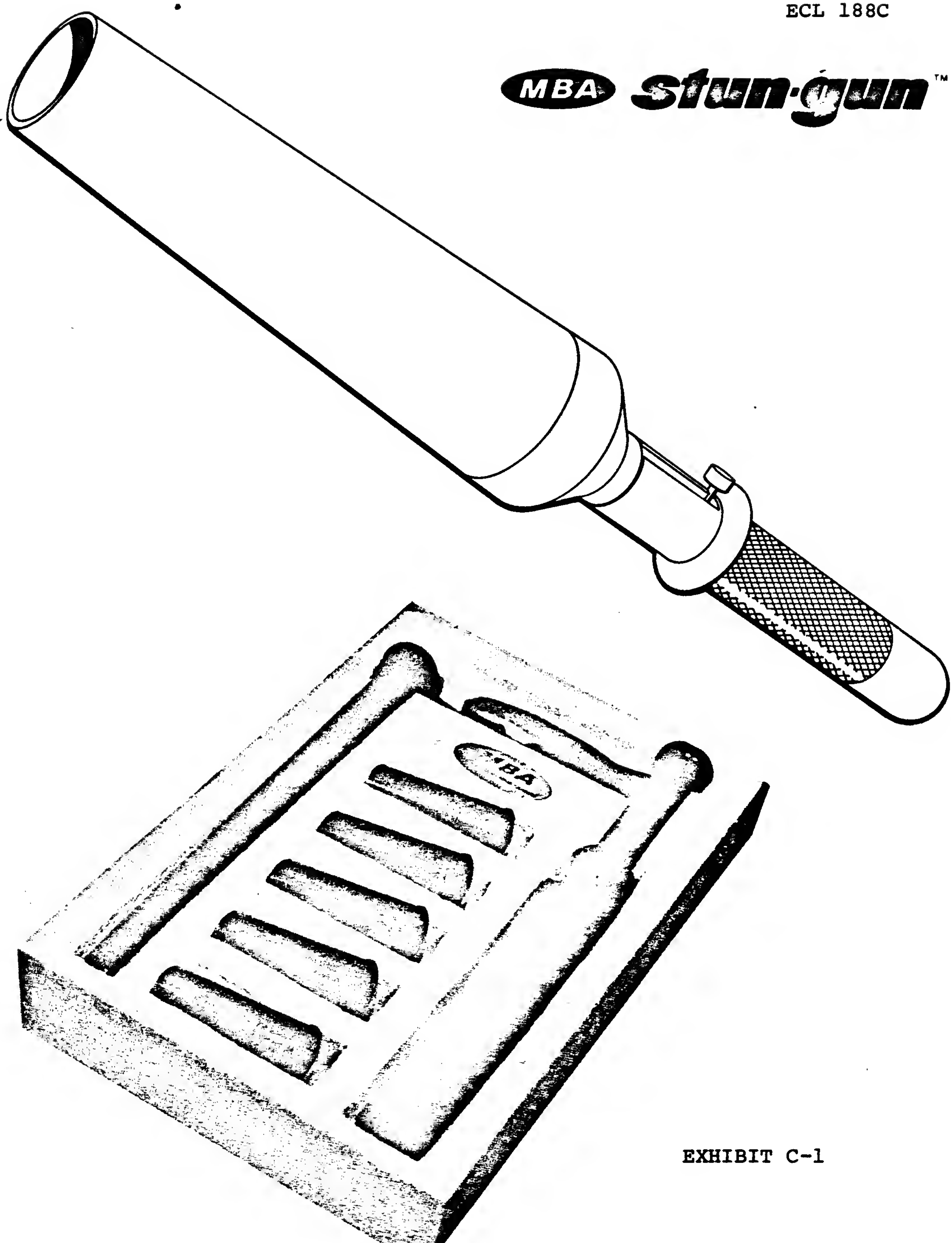
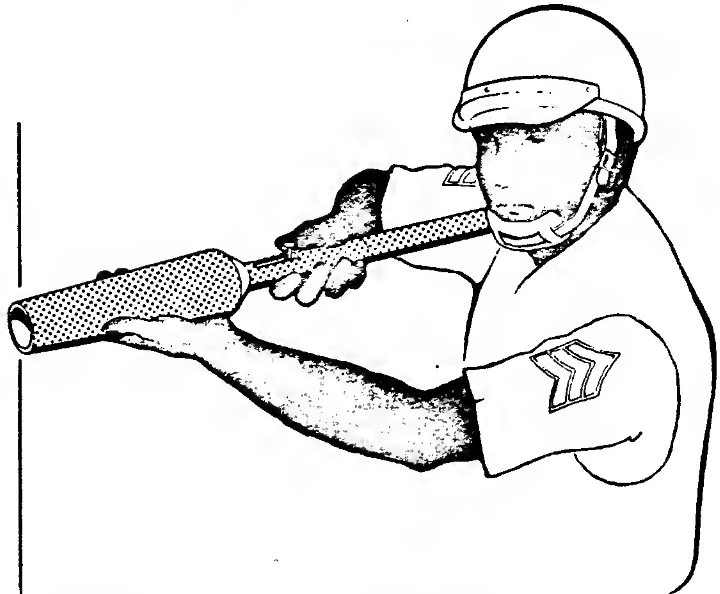


EXHIBIT C-1

MBA stun-gun™

READY AS A NIGHT STICK

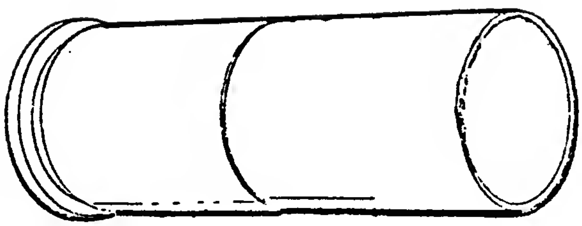


READY IN SHOULDER POSITION WITH SHOULDER STOCK ADAPTER

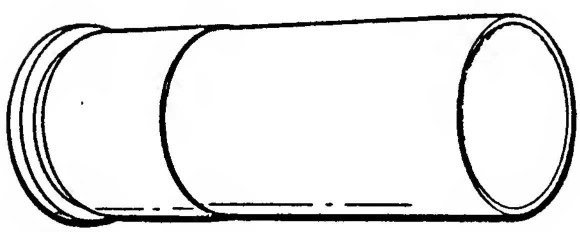
HIP FIRE POSITION

READY TO USE IN CROWD CONTROL SITUATIONS AS A RIOT BATON WITH SHOULDER STOCK ADAPTER

EXHIBIT C-2



MILITARY M-79 CARTRIDGE



STUN-GUN CARTRIDGE

EXHIBIT C-3

MBA news brief

MBAssociates SAN RAMON, CALIF. 94583 • (415) 837-8181 • TWX 910-389-6390 • CABLE MBAssoc

On December 1, 1970, MBAssociates' Stun-Gun received its most critical test to date. The incident was the demonstration at the Fairmont Hotel in San Francisco on the occasion of the visit of Vice President Ky of South Vietnam. The Stun-Gun was deployed by the 1st Platoon of the San Francisco Police Department under the command of Captain Jeremiah P. Taylor, Lieutenant Charles Schuler and Sergeant Daniel P. Howard.

Following are extractions from the official San Francisco Police Department account.

FIELD EVALUATION REPORT - 12/4/70

Since the action took place, at least for this unit, in two distinct parts the impressions of the gunners themselves and the comments of the other officers committed were collected after each incident and are presented in that manner.

1st Deployment. Calif. & Powell Sts. Sweep Westward.

Officers were committed to the sweep in a skirmish line with assigned Stun Gunners on line in the same position as if equipped with a baton. Stun Guns were altered by us by application of a lanyard to assist in aiming from the hip.

REACTIONS:

Crowd: Front rank became aware of the new weapon almost immediately and much speculation followed as to its purpose. Faint hearts moved deeper into the crowd and the more hardened disturbers made a point of not standing directly in front of the muzzle. No one was seen to throw rocks at this point and actually as the line advanced a number of discarded rocks and bricks were found in the street.

Police: On the first sweep the gunners and the men around them commented favorably on the crowd's obvious uneasiness at an unknown weapon and the comparative ease of moving the crowd uphill, because those threatened fell back taking others with them. During this phase the Stun Gun was used only three or four

times as a baton and then for simply jabbing. To avoid making numerous quotes it can be said that the men were very favorably impressed with the crowd's fear of an unknown quantity and were fearful of taking aggressive actions because of the possible consequences.

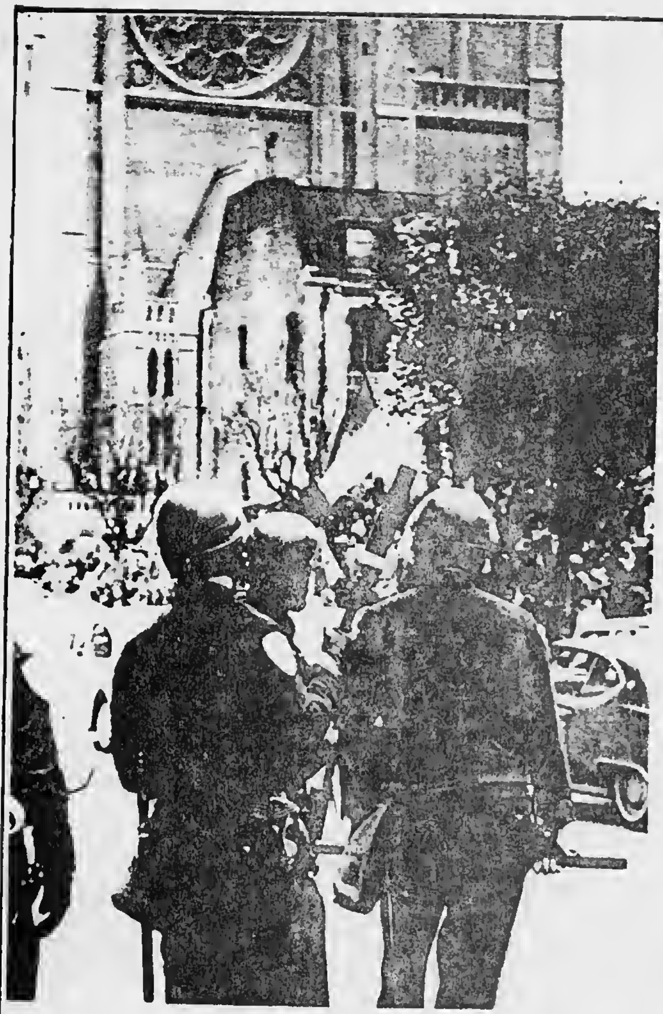
2nd Deployment. Calif. West of Powell St. to conclusion.

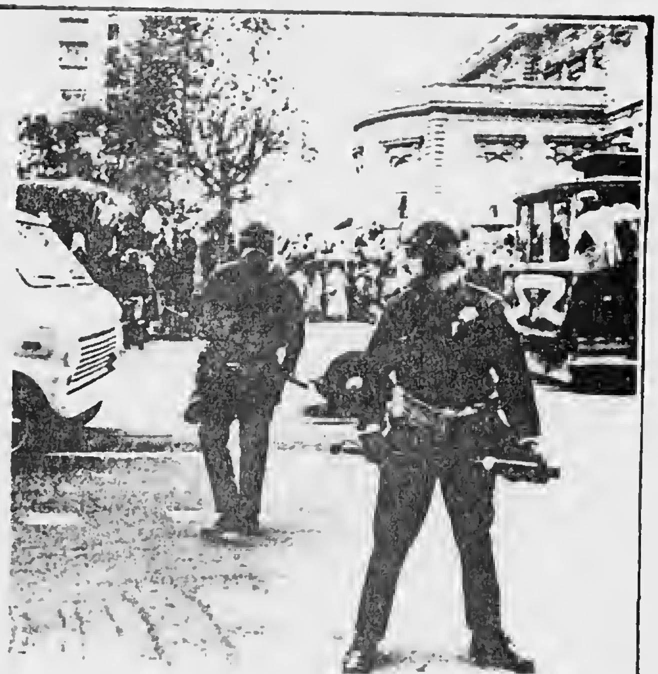
Crowd: Now split into many groups but most aggressive persons began the rockthrowing from Huntington Plaza and our unit was the object of many missiles from that group. Many targets were within fifty feet as the crowd was swept from the plaza by the horses. Use of the gun at this point would have resulted in several arrests and probably broken up the crowd. The crowd that went West on Calif. was chased by us and the group on the South side that attacked Officer Matisek were driven off by Officer Ligouri threatening them with the Stun Gun. In one situation West of Taylor, a group that showed intentions of attacking a lone officer making an arrest was driven off by one Stun Gunner. It appears the mob felt the weapon would be used to prevent mob action on a police officer, at least they did not test this theory.

Police: Two of the officers assigned used the weapon as a baton during the second stage of the action and reported satisfactory results and since both of these men are excellent with the regular baton, the fact that the Stun Gun remained intact during such use speaks highly for its strength. The men assigned the weapon followed their orders exactly and felt a great personal responsibility about using it.

* * *

It can be concluded that the Stun-Gun successfully met this challenge, and can take its place as an important weapon in the field of riot and crowd control in addition to its proven value in the day-to-day operations of police departments and other law enforcement agencies.





Photographs of the MBA STUN-GUN[tm] in action on December 1, 1970, at the demons during the visit of Vice President Ky of South Vietnam to San Francisco. The STUN-C was deployed with the 1st Platoon of the San Francisco Police Department.

EXHIBIT C-4

Excerpts from the *San Francisco Chronicle*, Friday 24 July 1970

A BEAN BAG FOR RIOT CONTROL
Prototype Going to Berkeley

by
Don Wegars

A strange development in weaponry is under way in this age of nuclear potential. The bean bag.

That's right. A bean bag that leaves the muzzle of a gun at a speed of about 120 miles an hour to land 100 feet away with surprising accuracy and the power of a championship right cross.

The bean bag gun - formally called a "stun gun" - was unveiled yesterday by MBAssociates, an ordinance firm located on a hillside in sparsely populated southern Alameda County.

The gun, a 40 millimeter grenade launcher, fires no ordinary bean bag. The sewn canvas bag is stuffed with number 8 birdshot and weighs about half a pound. It is stuffed into something like a large shotgun shell and expands to 4-1/2 in. in diameter when leaving the muzzle.

It comes at you - fast - like a medium sized pancake or a lead hamburger

Its inventor hopes it is the ideal weapon for police to use in crowd control work and for apprehending suspects - areas where many observers feel the police have either too little or too much power - night sticks or pistols.

"It will hurt when it hits," Robert Mawhinney said yesterday. "But our tests show that it shouldn't break bones or puncture skin."

Mawhinney, a young recent University of California at Berkeley graduate, evolved the idea of the bean bag gun after students were killed by National Guardsmen at Kent State University.

The basic principle, he said, is that the bag makes contact with the person over a relatively large area with a large force. Because the barrel is rifled, the bag leaves the muzzle spinning and hits flat.

"It should give the police a medium choice response," Mawhinney said. "Something between just ignoring a guy who's throwing rocks or shooting him with a pistol."

A prototype is on its way to the Berkeley police who said yesterday they would take it into the field for tests "if the occasion comes up, like another riot."

So far no tests have been made on humans although the bags have proved satisfactory when run through tests designed to study auto crashes.

The effect of getting hit with a bag, Mawhinney said, would range from being knocked down to being left breathless. There would be some abrasions and the effect, he said, "would not be pleasant."

EXHIBIT C-5

ECL 188C

MBAssociates

SAN RAMON
(NEAR SAN FRANCISCO)
CALIFORNIA
94583

TELEPHONE
AREA CODE 415
837-7201

Dear Sir:

MBA's new Stun-Gun was introduced publicly at the recent International Association of Chiefs of Police Convention in Atlantic City. Law enforcement professionals throughout the United States and from many foreign countires are enthusiastic about this new and unique device because it gives them--for the first time--a highly effective but non-lethal means of controlling unruly crowds and individuals from point-blank range to over 100 feet.

Many agencies have already ordered enough units to test the Stun-Gun under actual operational conditions. We are making every effort to fill the first orders from each agency on a high priority basis so that the full versatility of the Stun-Gun can be quickly realized. A special postage-paid card is enclosed to insure that your department will receive the required units at an early date.

THE STUN-GUN SYSTEM

The Stun-Gun System consists of the Stun-Stik which fires the Stun-Bag and is also fully serviceable as a night stick. Additionally, a riot baton extension converts the Stun-Stik to the proper length for controlling crowd movements and for long-range aiming accuracy. The cartridges are of highest quality materials and are reloadable for as little as 25 cents per round. Five reloadable cartridges are included in each complete unit.

The Stun-Gun is the most versatile device in law enforcement weaponry. In addition to serving as a night stick or riot baton while instantly ready for firing its non-lethal Stun-Bag; a variety of special order cartridges are available. These include dye marking, multiple baton (wooden blocks), flare and smoke signaling, line throwing, plastic shot and noise confusion rounds.

Expert legal counsel in the police field advises that the Stun-Gun and the effects of its usage create no new legal implications.

HOW IT WORKS

The specially designed Stun-Bag, fired at 110 miles per hour from the Stun-Gun cartridge, is a collapsed, 1/2 pound pancake-like projectile. It instantly opens to 4 inches in diameter at the muzzle and travels stably and accurately to the target. By way of example:

Distance From Muzzle	Shocking Power Compared to a Professionally Fast-Pitched Baseball
Point Blank	2 Times
50-60 Feet	Equal
100 Feet	Two-thirds

However, unlike the injurious characteristics of a round, hard baseball, MBA's Stun-Bag--even though it delivers more shocking power--impacts the target flat without causing permanent injury.

TESTING

To verify the non-lethality of the Stun-Gun System, Bio-Mechanical tests have been conducted by Verne L. Roberts, Ph.D., a special consultant in this field. Additional, human target testing has been complete. Results confirm that effects are significantly below the range of permanent injury, but well into levels of pain.

* * * * * * * * * *

Enclosed for your convenience, are several sets of the Stun-Gun information that you may want to route to key people. Postage-paid cards, also enclosed will assure you of priority deliveries.

If you have any additional questions or need any assistance in placing an initial order, feel free to call me collect.

Sincerely,

R. Mainhardt

R. Mainhardt
President,
MBAssociates

EXHIBIT C-5